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Indian Standard

GUIDE FOR TREATMENT AND DISPOSAL OF EFFLUENTS OF WOOL PROCESSING INDUSTRY

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NEW DELHI 110002

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GUIDE FOR TREATMENT AND DISPOSAL OF EFFLUENTS OF WOOL PROCESSING INDUSTRY

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Indian Standard

GUIDE FOR TREATMENT AND DISPOSAL OF EFFLUENTS OF WOOL PROCESSING INDUSTRY

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 28 February 1983, after the draft finalized by the Water Sectional Committee had been approved by the Chemical Division Council.

0.2 The woollen industry in India has undergone fast development during the last 25 years. A large variety of woollen fabrics of the highest quality, both woven and knitted, are manufactured by the mills. Most of the mills are located in the states of Maharashtra, Punjab, Haryana, Rajasthan, Gujarat, Karnataka, West Bengal, Himachal Pradesh and Jammu & Kashmir.

0.3 The mills are mostly situated in urban areas and do not have suitable arrangement for collection and disposal of the waste water. The waste waters generated during processing of wool are strong wastes and are highly pollutional. The wastes are normally discharged as such without treatment.

0.4 The object of this standard is to provide suitable guidelines on treatment and disposal of above effluents. The methods recommended have been chosen taking into consideration the practicability of their adoption in India. The standard does not seek to provide detailed information on the manufacturing process or on the design and operation of the effluent treatment plants. When better and more economical methods of treatment become available, revision of this standard will be taken up. A list of relevant references is given in Appendix A.

0.5 It is recommended that plants located near the sea may preferably discharge their effluents into the marine coastal areas rather than into inland surface water. The extent of pollution of marine coastal areas permitted by discharge of effluents is laid down in IS : 7967-1976*. The extent of pollution of inland surface waters permitted by discharge of effluents is laid down in IS : 2296-1982†.

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*Criteria for controlling pollution of marine coastal areas.

†Tolerance limits for inland surface waters subject to pollution (*second revision*).

0.6 IS : 2490 (Part 1)-1981* lays down the tolerance limits for industrial effluents discharged into inland surface waters, marine coastal areas, public sewers and on land for irrigation purposes.

0.7 Methods of sampling and test for industrial effluents are covered in IS : 2488 (Part 1)-1966†, IS : 2488 (Part 2)-1968†, IS : 2488 (Part 3)-1968†, IS : 2488 (Part 4)-1974)† and IS : 2488 (Part 5)-1976†.

1. SCOPE

1.1 This standard covers methods of treatment and disposal of waste waters generated during the processing of raw wool and woollen fabrics. It includes available data and information on the sources, characteristics, volumes, pollutional effects of the effluents, ways of waste prevention and methods of their treatment and disposal.

2. PROCESS INVOLVED IN WOOLLEN INDUSTRY

2.1 Raw wool as received by the industry from the collection centres contains appreciable amounts of natural impurities which are derived mostly from the glandular secretion of the sheep, like suint and woolgrease and also acquired impurities like dust, dirt, straw, organic matter of vegetable and faecal origin including bio-organisms. It may also contain applied impurities like chemicals and pesticides and tar or paint. The raw wool contains only about 40 percent fibre.

2.2 The basic processes of preparing the woollen fibre from raw wool are almost the same in all the mills but the dyeing and printing process, however, may be different.

The sequence of operations in a woollen mill is shown in Fig. 1. The important processes consist of the following:

a) Scouring of raw wool;

b) Carding, combing, spinning and weaving;

c) Rilling and finishing; and

d) Dyeing.

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*Tolerance limits for industrial effluents: Part 1 General limits (*second revision*).

†Methods of sampling and test for industrial effluents: Parts 1 to 5.

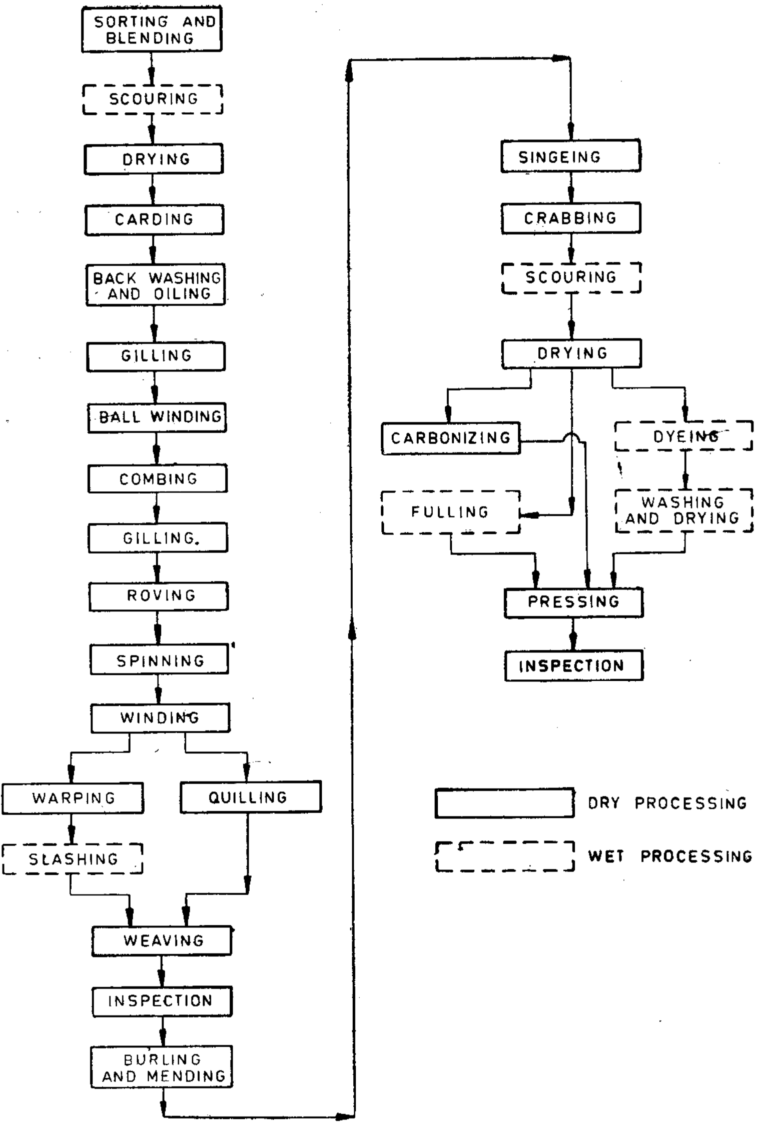

FIG. 1 WOOL PROCESSING FLOW SHEET

2.2.1 *Scouring of Wool* — The scouring of wool consists of removal of natural and other impurities by treating the raw wool with a hot chemical solution made up of soaps, alkali, detergents and soda ash. This is a multistage operation. In the first stage scouring is done with soap and alkali (usually sodium carbonate) at a temperature of 52 to 54°C. The alkali saponifies the fatty acids of the wool grease. The soap emulsifies the wool fat and forms suspensions of light dirt particles. In the next step detergent and sodium carbonate are used. This is followed by a second scouring with soap and alkali and a further treatment with detergent and sodium carbonate with an intermediate and final rinsing with water. After each wash the wool passes through a set of squeeze rolls by means of which the adherent dirty liquor is removed. This liquor is allowed to settle and recycled to the front end of each bowl.

2.2.1.1 *Solvent scouring* — In the solvent process for scouring, the raw wool is treated with an organic solvent, instead of detergent solution. The wool grease dissolves in the solvent and is recovered and purified. The solvent is recovered and reused. The economics of this process, however, depends on efficient recovery of the solvent.

2.2.2 *Carding, Combing, Spinning and Weaving* — These are dry processes and are mechanized. The pads of fibre are opened out and paralleled. Next combing is done to remove any unwanted material, then the wool is drawn into a continuous rope form and further spun into the yarn. At this stage the yarn is slashed with starch as the main sizing material and then woven into cloth. The woven material is subjected to mending to rectify any defects.

2.2.3 *Finishing* — The sequence of operations consist of singeing, crabbing, scouring, drying, carbonizing, fulling, dyeing of the woven fabric, washing, pressing and inspection.

2.2.3.1 *Fulling* — This is a wet process and imparts a felt quality to the wool. Soap is used as the felting agent and little waste is generated since the solution remains in the cloth itself. At this point in the processing the woollen fabric contains considerable process chemicals. The cloth is washed, squeezed between rollers and a final rinsing in a water bath completes the removal of process chemicals.

2.2.3.2 *Carbonizing* — The last of residual vegetable or other organic impurities in the wool fabric is removed by carbonizing with 4 to 6 percent sulphuric acid and then oven-dried at 100-105°C. As the moisture evaporates, the organic matter is charred. The fabric is then passed through rollers to crush the charred matter which is subsequently removed by dusting. The fabric is next rinsed with a dilute solution of soda ash, washed again and dried.

2.2.4 *Dyeing* — Dyeing of wool is carried out after scouring in the form of tops or dyed and finished after spinning and weaving. The dyeing process is followed by washing. The process produces a large volume of waste.

3. USAGE OF WATER

3.1 Considerable volume of water is used in wet processing of wool. The usage of water varies from one mill to another, as shown in Table 1, and even within the same unit the consumption of water varies according to the nature of processing.

TABLE 1 DATA ON WATER CONSUMPTION IN WOOL PROCESSING PLANTS

MILL No.	PRODUCTION RANGE	CONSUMPTION OF WATER	CONSUMPTION OF WATER PER kg OF WOOL PROCESSED
(1)	(2)	(3)	(4)
	(kg/day)	(m^3/day)	(litres/kg)
i)	1 000	345	345
ii)	1 555	562	361
iii)	460	64	138
iv)	3 800	2 615	690

4. SOURCES, QUANTITIES AND CHARACTERISTICS OF EFFLUENTS

4.1 Sources — The main sources of waste water from a woollen mill are the following (*see* Fig. 1):

a) *Scouring of Wool* — Detergent scouring, steeping, scour bowls and rinse bowls;

b) *Slashing* — The wastes from sizing of wool.

c) *Dyeing and Finishing Process* — Consisting of spent liquors from dyeing and subsequent washings;

d) *Miscellaneous Waste Stream* — Derived from singeing, bleaching finishing and washings at the end of each process.

e) *Boiler Blowdown and Sanitary Wastes*

4.2 Quantities of Waste Water — The bulk of the waste water in a woollen mill is generated from the different washing and rinsing operations at the end of each wet process, as shown in Table 2.

TABLE 2 VOLUME OF WASTE WATER GENERATED AT DIFFERENT STAGES OF PROCESSING

(*Clause* 4.2)

SL No.	WET PROCESS	VOLUME OF WASTE WATER LITRE/kg OF WOOL PROCESSED	PERCENT OF TOTAL
(1)	(2)	(3)	(4)
i)	Scouring	37	6·6
ii)	Stock dyeing	24	4·3
iii)	Washing	325	58·1
iv)	Fulling	45	8·1
v)	Neutralization after carbonizing	125	22·4
vi)	Optical bleach	3	0·5

4.3 Characteristics of the Process Waste Waters

4.3.1 *Scouring Wastes* — The waste waters from scouring process are characterized by high content of soaps and grease. As the scouring operation is carried out at high temperature in the range of 45 to 54°C the waste water has a high temperature. The *p*H, biological oxygen demand (BOD) and chemical oxygen demand (COD) of the wastes are also high. The characteristics of waste of wool scouring are shown in Table 3.

TABLE 3 CHARACTERISTICS OF SCOURING WASTES

SL No.	CHARACTERISTIC	MILL 1	MILL 2	MILL 3
(1)	(2)	(3)	(4)	(5)
i)	*p*H value	7·9	8·0	6·6 to 6·9
ii)	Alkalinity (as $CaCO_3$), mg/l	—	4 310	—
iii)	Total dissolved solids, mg/l	—	12 600	—
iv)	Suspended solids, mg/l	4 000	20 150	—
v)	Biochemical oxygen demand (5 days at 20°C), mg/l	10 000	10 500	14 000 to 22 750
vi)	Chemical oxygen demand, mg/l	—	53 130	62 800 to 77 600
vii)	Oil and grease, mg/l	10 000	19 970	8 960 to 17 800

4.3.2 *Dyeing Process Wastes* — Waste waters from the dyeing process consisting of the spent liquors and washings, show a considerable variation in regard to their volume and characteristics from one mill to another. The characteristics of the wastes are shown in Table 4.

TABLE 4 CHARACTERISTICS OF WASTES FROM DYEING OF WOOL

(*Clause* 4.3.2)

SL No.	CHARACTERISTIC	MILL 1	MILL 2	MILL 3	MILL 4
(1)	(2)	(3)	(4)	(5)	(6)
i)	*p*H value	3 to 6	6·2	6·0	6·5
ii)	Total dissolved solids, mg/l	—	1 310	5 408	13 804
iii)	Suspended solids, mg/l	30	40	226	140
iv)	Biochemical oxygen demand (5 days at 20°C), mg/l	3 000	200	298	130
v)	Chemical oxygen demand, mg/l	—	580	580	856
vi)	Oil and grease, mg/l	80	—	8	30

4.3.2.1 Results of another study are shown in Table 5 for dyeing and finishing wastes.

TABLE 5 CHARACTERISTICS OF DYEING AND FINISHING WASTES FROM WOOLLEN MILLS

SL No.	CHARACTERISTIC	MINIMUM VALUE	AVERAGE VALUE	MAXIMUM VALUE	90 PERCENT OF SAMPLES WERE LESS THAN OR EQUAL TO
(1)	(2)	(3)	(4)	(5)	(6)
i)	*p*H value	5·3	—	9·6	—
ii)	Suspended solids, mg/l	10	230	1 830	715
iii)	Biochemical oxygen demand (5 days at 20°C), mg/l	8	260	1 313	610
iv)	Chemical oxygen demand mg/l	20	860	3 960	2 440
v)	Oil and grease, mg/l	1·4	155	1 124	560
vi)	Acidity (as $CaCO_3$), mg/l	10	70	220	220
vii)	Alkalinity (as $CaCO_3$), mg/l	5	100	248	240
viii)	Dissolved oxygen, mg/l	0	0·85	5·93	2·1

4.3.3 *Combined Wastes* — The combined waste water discharged from the mills vary in characteristics, not only on account of the quantity of water used by different mills, but also because of the various type of dyes and process chemicals used. The characteristics of the combined wastes are given in Table 6.

TABLE 6 CHARACTERISTICS OF COMBINED WASTES

(*Clause* 4.3.3)

Sl No.	Characteristic	From Woollen Mills in India				From Literature Survey		
		Mill 1	Mill 2	Mill 3	Mill 4	1	2	3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	*p*H value	5 to 8	6 to 8	7·0	7·3-7·4	9·3	7·3 to 10·4	—
ii)	Total dissolved solids, mg/l	—	—	5 216	1 840-1 916	21 080	—	—
iii)	Suspended solids, mg/l	500 to 4 000	1 000	366	144-180	3 020	—	—
iv)	Biochemical oxygen demand (5 days at 20°C), mg/l	1 000 to 5 000	1 500 to 2 500	204	100-160	1 770	170 to 21 300	4 290
v)	Chemical oxygen demand, mg/l	—	4 500 to 7 500	330	576-648	—	—	—
vi)	Grease, mg/l	1 000	1 000	12	63-72	7 130	—	9 120
vii)	Percent sodium	—	60	86	—	—	—	—

5. POLLUTION LOAD

5.1 The combined waste water discharged from the wool processing mills contains a large amount of total dissolved and suspended solids, BOD, COD and oil and grease. Amongst the various process wastes the major pollution load is contributed by the scouring waste, which amounts to 50 to 75 percent of the BOD and 58 percent of alkalinity. Wool scouring effluent contains wool grease also in highly emulsified form. Next in order is the waste water from washings which contributes about 50 percent of the BOD. The pollution load from three woollen mills is shown in Table 7.

TABLE 7 POLLUTION LOAD FROM TYPICAL WOOL PROCESSING MILLS

Sl No.	Unit Process	BOD Load kg/1 000 kg of Wool			Percent BOD		
		Mill 1	Mill 2	Mill 3	Mill 1	Mill 2	Mill 3
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	Scouring	104·5	226·7	906·2	42	74·3	40
ii)	Stock dyeing	34·3	10·3	54	14	3·4	7·3
iii)	Washing after fulling	94	66	—	37	21·6	—
iv)	Others	18·1	2·1	7·7	7	0·7	1

6. POLLUTIONAL EFFECTS

6.1 Effects on Receiving Streams — The waste waters from woollen mills have the following effects on receiving bodies of water:

a) *Physical Effects* — Due to colour, turbidity and odour;

b) *Temperature Effects* — Caused by the high temperature of process waste stream like the scouring waste;

c) Effects of *p*H;

d) *Increase in Total Dissolved Solids* — Due to high total dissolved solids of the wastes;

e) *Deoxygenation* — High BOD of the waste will result in deoxygenation;

f) *Scum* — Fatty acids and wool grease may create a floating scum on the surface of water; and

g) Effect on organoleptic properties and animal and plant life.

6.2 Effects on Land — Discharge of waste waters on land may cause the same ill effects as other wastes having high BOD.

6.3 Effects on Sewers — High BOD of the wastes may increase the organic loading of municipal sewage plants. Large amounts of wool grease along with suspended solids may be deposited in the sewers resulting in obstruction of flow and eventually cause reduction in the hydraulic capacity of the sewers. However, the wastes may be permitted to be discharged into sewers in a controlled manner after treatment of the wastes.

7. TREATMENT OF WOOL PROCESSING WASTES

7.1 Treatment of wool processing waste waters has the following objectives:

- a) Reduction of waste load by i) by-product recovery, ii) process modification, and iii) substitution of process chemicals.
- b) Screening for removal of large floating solids.
- c) Floatation for removal of wool grease. However acid cracking may be necessary to prevent foaming and for easy removal of wool grease.
- d) *Chemical Treatment* — Consisting of chemical coagulation, flocculation and settling.
- e) Biological treatment of the wastes for BOD reduction by anaerobic digestion/aerobic treatment.

7.1.1 *Reduction in Waste Load*

7.1.1.1 *Recovery of by-products* — Wool grease and suint in raw wool amount to about 60 percent and they can be recovered as saleable by-products. Wool grease has a high content of the fatty acid lanolin which is used as an important ingredient in the cosmetic industry.

7.1.1.2 *Process modifications* — Removal of grease from raw wool by solvent extraction methods is one of the means of reducing stream pollution from conventional chemical scouring processes and is reported to be used for production of high grade wool grease. A petroleum fraction is used as solvent on batch basis. Chlorinated hydrocarbon solvents are less hazardous from the point of view of fire and explosion, but may not be economical.

7.1.1.3 *Substitution of chemicals* — Low BOD detergents, for soaps, may be used for lowering BOD of the waste. Use of dyes which exert low BOD is yet another step towards BOD reduction.

7.1.2 *Screening* — Screening of the wastes for removal of coarse floating matter is done using conventional screening devices used in waste water treatment.

7.1.3 *Floatation* — The residual grease and fatty acids in the combined wastes may easily be removed by floatation techniques.

7.1.4 *Chemical Treatment*

7.1.4.1 *Treatment with acid* — Waste water from the wool scouring process is strongly alkaline and contains considerable amount of grease. One of the earliest methods developed for treatment of this waste is by neutralization with sulphuric acid followed by sedimentation.

7.1.4.2 *Chemical coagulation* — Chemical coagulation consists of the following:

a) *Flash mixing* — Wherein the incoming waste is intimately mixed with chemical coagulant aids and chemicals used for neutralization, etc;

b) *Flocculation* — In order to hasten the agglomeration of the flocs, the waste is flocculated by paddles. The flocculation time is in the range of 15 to 45 minutes; and

c) *Clarification of waste* — Carried out in a clarifier of conventional design.

The common coagulants used are (a) Alum, (b) Copperas, (c) Ferrous sulphate, (d) Ferric chloride, and (e) Calcium chloride. The coagulant aids that may be helpful are bentonite and polyelectrolytes. Overall efficiency of BOD reduction by various chemical treatment processes is reported to be as follows:

Sl No.	*Chemical used*	*Percent reduction in BOD*
1.	Calcium chloride	40-70
2.	Lime + Calcium chloride	60
3.	Alum	20-56
4.	Copperas	20
5.	Ferrous sulphate	50-80
6.	Sulphuric acid + Ferric chloride	59-84

7.1.5 *Biological Method* — The conventional methods of aerobic and anaerobic treatment are also applicable for treatment of the waste water from wool scouring as well as the combined wastes.

7.1.5.1 *Trickling filter* — With proper planning, equalization of the wastes in holding tanks of adequate capacity and *p*H control by chemicals whenever needed, trickling filters are reported to give satisfactory results. It is reported that BOD reduction in the range of 80 to 85 percent has been achieved. The recommended BOD loadings are 0·35-0·5 kg/m^3.

7.1.5.2 *Activated sludge* — Conventional activated sludge and its modifications are also suitable for treatment of wool scouring wastes and combined wastes for BOD reduction in the range of 85 to 90 percent has been reported.

7.1.5.3 *Anaerobic treatment* — Pilot plant studies on anaerobic digestion of wool scouring wastes indicate that with a waste containing 28 000 mg/l volatile solids and BOD about 10 000 mg/l, BOD reduction of 82 percent was feasible; the detention period being 20 days and digester loading 0·96 kg/m^3.

7.1.5.4 *Low cost waste treatment methods* — The low cost waste treatment methods like the waste stabilization pond, oxidation ditch and aerated lagoon may also be suitable provided a combination of anaerobic and aerobic methods is adopted on account of the high concentration of organic constituents.

7.1.5.5 *Treatment alternatives* — Based on detailed inplant surveys, the following treatment alternatives are proposed for treatment of wool processing wastes:

a) Combined chemical and aerobic biological treatment consisting of equilization, chemical coagulation (flocculation and sedimentation), aeration (conventional activated sludge) final clarifier and sludge disposal as shown in Fig. 2;

b) Two-stage biological treatment consisting of anaerobic digestion followed by extended aeration (oxidation ditch), final sedimentation and sludge recycle, as shown in Fig. 3 preceded by equalisation, clariflocculation and settling;

c) Two-stage biological treatment consisting of anaerobic lagoon followed by oxidation ditch with sludge recycle and final sedimentation, as shown in Fig. 4 preceded by equalisation, clariflocculation and settling;

d) Two stage biological treatment consisting of equalisation and anaerobic lagoon, followed by oxidation pond, as shown in Fig. 5;

e) In-plant treatment of wool scouring effluent with acid cracking and settlement. Mixing of this partly treated effluent with other streams and chemical treatment of this combination by lime and ferrous sulphate; and

f) In-plant treatment of wool scouring effluent as in (e) above and treatment of this combination by aerated lagoons.

NOTE — Concentrated wastes, for example scouring waste may be segregated, treated for grease removal/recovery and then combined for further treatment along with other effluent streams.

The essential features of the design criteria for the two stage biological treatment systems are shown in Table 8.

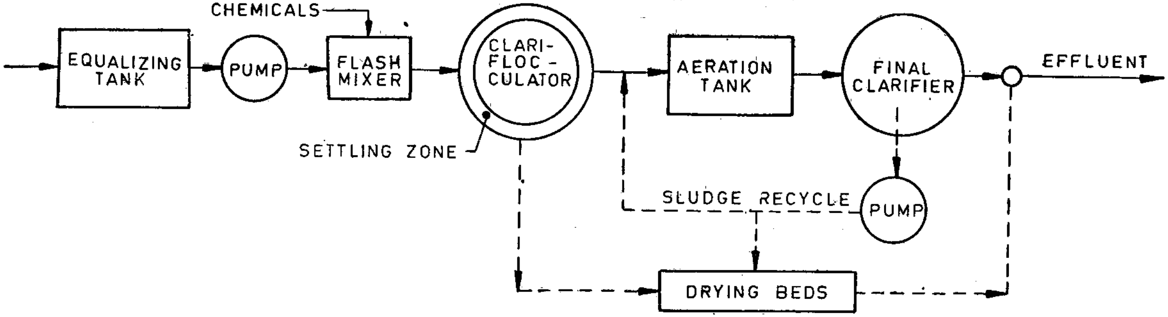

FIG. 2 SCHEME 1 FOR TREATMENT OF EFFLUENT

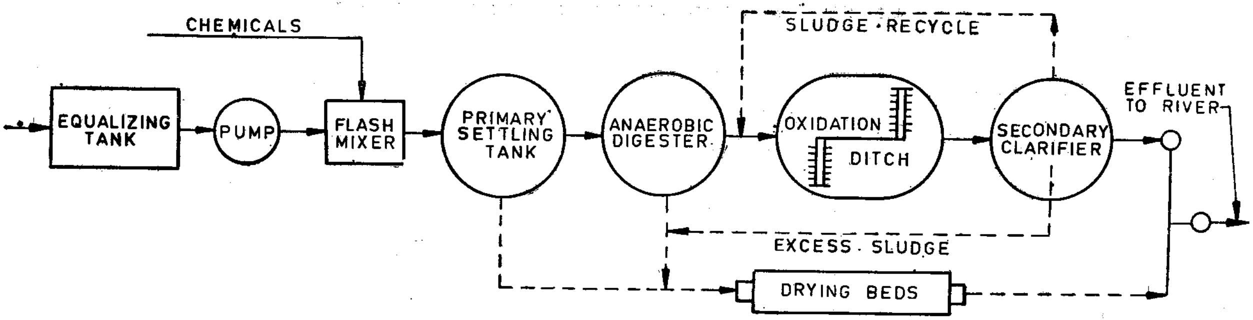

FIG. 3 SCHEME 2 FOR TREATMENT OF EFFLUENT

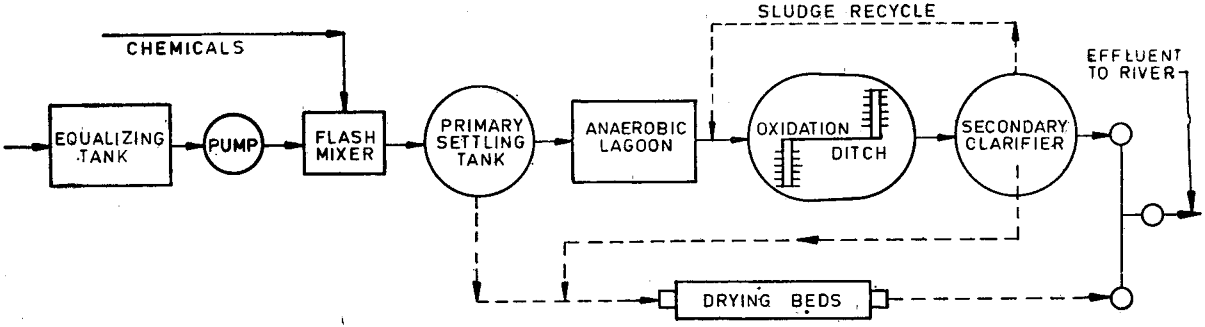

FIG. 4 SCHEME 3 FOR TREATMENT OF EFFLUENT

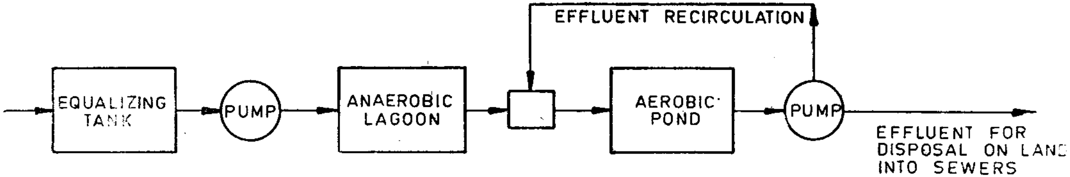

FIG. 5 SCHEME 4 FOR TREATMENT OF EFFLUENT

TABLE 8 DESIGN CRITERIA FOR TWO STAGE BIOLOGICAL TREATMENT

(*Clause* 7.1.5.5)

SL No.	OPERATION	DESIGN CRITERIA		
		Scheme 2	Scheme 3	Scheme 4
1.	Equalization	8 hours	8 hours	—
2.	Anaerobic treatment	Anaerobic digestion	Anaerobic lagoon	Anaerobic lagoon
	a) Detention time	6 days	10 days	10 days
	b) BOD of raw waste	2 000 mg/l	2 000 mg/l	2 000 mg/l
	c) BOD loading rate, kg/m^3 day	0·288	0·224	0·224
	d) BOD reduction	—	70 percent	70 percent
3.	Aerobic treatment	Oxidation ditch	Oxidation ditch	Oxidation pond
	a) MLSS	4 000 mg/l	4 000 mg/l	—
	b) BOD loading rate	0·075 kg/kg MLSS	0 075 kg/kg MLSS	140 kg/Hect day
	c) Detention period	—	—	45 days
	d) BOD of treated effluent	—	—	60-100 mg/l

7.2 Methods Recommended for Adoption

7.2.1 Reviewing the methods outlined in **7.1**, it is recommended that a scheme for complete treatment of composite effluents from wool processing industries should consist of the following.

7.2.1.1 Grease removal/recovery by in-plant treatment of wool scouring effluent.

7.2.1.2 Equalization of waste.

7.2.1.3 Primary treatment consisting of (a) screening for removal of floating matter, (b) chemical coagulation, flocculation and sedimentation for removal of colour, grease and suspended and settleable solids.

7.2.1.4 Secondary treatment consisting of biological treatment by a suitable combination of anaerobic treatment followed by aerobic treatment processes for BOD reduction, either on conventional pattern or the low cost biological treatment methods.

7.2.2 The degree of treatment required depends on the ultimate mode of disposal of effluents into the environment, that is, discharge into public sewers, or surface streams or directly into the sea.

7.2.2.1 For discharge into municipal sewers, the degree of treatment may be limited to primary treatment and anaerobic treatment and for discharge into inland surface waters, the two secondary treatments consisting of anaerobic treatment followed by aerobic treatment will apply. The degree of dilution available in the receiving stream also is a factor to be reckoned with.

7.2.2.2 For land disposal, primary treatment and secondary treatment are required.

APPENDIX A

(*Clause* 0.4)

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